Computational Thinking:

A Problem-Solving Tool for Every Classroom

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CS & IT 2008

csta

We do not acquire technical skills simply from the use of technology any more than engineering skills evolve from using automobiles or aeronautical engineering skills from flying.

Robert Tinker, Alvaro Galvis, and Andrew Zucker
The Concord Consortium

Our Plans

- What is computational thinking?
- Why is it important to think about?
- How has it changed the world we live in?
- How can it enhance learning for students?
- What can happen in classrooms to implement computational thinking strategies?
- How can we use this concept to expand CS influence and appeal?
- Opportunities to share throughout

Something to consider

The type of thinking required by citizens for successful participation in a society is related to the raw products available and the processes being applied to them in order to solve problems.

Industrial Activity

- Knowing about physical things and thinking about making/combining materials into new things.
- Terms you are likely familiar with:
  - Assembly-line
  - Automation
  - JIT—Just-In-Time processing
  - Industrial Arts
  - Fabrication
  - Drafting

Information Technology

Knowing how to apply technology to locate and use information in order to solve problems

- Terms we have become familiar with:
  - Telecommunications, email, cyberspace
  - Networks, MPG, LAN, modem, blog
  - WYSIWYG, desktop publishing
  - File, icon, chip, cursor
  - RFID, USB, DOS, RAM, GUI and on and on

Beyond Information Technology

- Knowing about data and ideas and using/combining these resources to solve problems.
- Move students beyond using tools and information to creating tools and information
- These raw materials require thought processes about manipulating data, using abstractions, lots of CS concepts
- We call it computational thinking

What is Computational Thinking?

….integrating human thinking with the capabilities of computers…..

How do we "computationally think?"

- Ask: What is the power and limit of human and computer intelligence?
- Ask: How difficult is the problem?
- Ask: How can it be solved?
- Ask: How can technology be applied to the problem?
- Ask: What computational strategies might be employed?

Tell me more….

- The underlying idea in computational thinking is developing models and simulation of problems
- It often requires a mathematical representation of the problem – like a story problem
- Mental modeling with the symbols and processes of other disciplines is required
- It will be a skill required for 21st Century success

What it's not…

- It's not just more technical details for using software
- It's not thinking like a computer
- CT ≠ programming
- It doesn't always require a computer
- It's not yet one more thing to add to the curriculum

Why is it important?

- It moves students beyond technology literacy
- It creates problem solvers instead of software technicians
- It emphasizes creating knowledge rather than using information
- It presents endless possibilities for creative problem solving
- It enhances the problem-solving techniques already taught

The New Pillars of Research

Theory Experimentation Computation

How does CT impact careers?

Engineering	4,790,000	**Art**	**546,000**
Physics	2,970,000	**Astronomy**	**524,000**
Biology	2,930,000	**Music**	**501,000**
Social science	2,030,000	**Economics**	**430,000**
Linguistics	1,670,000	**Agriculture**	**379,000**
Math	1,540,000	**Sociology**	**358,000**
Criminology	1,360,000	**Psychology**	**314,000**
Chemistry	1,150,000	**Philosophy**	**297,000**
Environment	1,060,000	**Game theory**	**189,000**

What has been accomplished?

- Computational
  - Physics
  - Biology
  - Chemistry
  - Mathematics
  - Computer Science
  - Law
  - Economics
  - Aeronautics
  - Education

It fits with the ISTE NETS

Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students:

- a. apply existing knowledge to generate new ideas, products, or processes.
- c. use models and simulations to explore complex systems and issues.
- d. identify trends and forecast possibilities.

NETS for Teachers

Monday, June 30 - New NETS for Teachers

Teaching, Learning, and the Curriculum

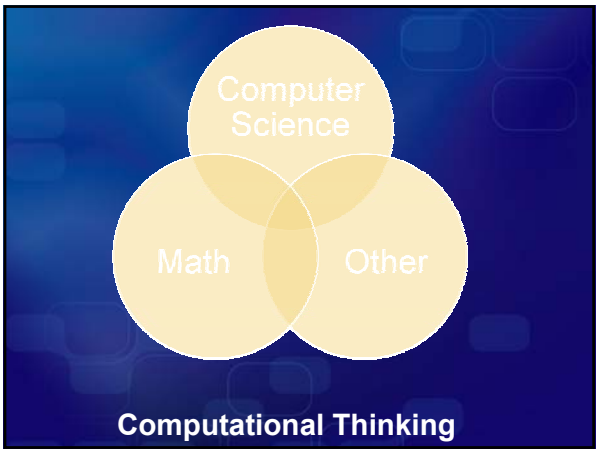
Teachers implement curriculum plans that:

A. facilitate technology-enhanced experiences that address content standards and student technology standards.

C. apply technology to develop students' higher-order skills and creativity

Computational Thinking Concepts

- Algorithm—the kingpin term
- Data—variables, data bases, Queue
- Abstraction—conceptualizing, modularizing
- Query—search, conditionals, Boolean
- Sensing & Feedback—robotics
- Iterations—loops, recursion
- Systems



So what can happen in other classroom?

- Math
- Biological Sciences
- Physical Sciences
- Social studies
- Language arts
- Fine arts
- Vocational subjects

So what can happen in the CS or IT classroom?

- Explore how problems in other fields are solved or modeled with CS
- Include the problems from other disciplines as the problems addressed in your class
- Move beyond programming or applications
- Discuss algorithms for big problems….problems beyond what they can currently solve
- Include topics such as robotics and media
- Think without a computer sometimes

Show me some real examples

- Big problems – Simulations
- Analyzing data
- Reach beyond your subject
- Explore CS topics in novel ways 1 2
- Explore ethical dilemmas in CS
- Keep 1 foot in the real world
- Use media
- Create your own models

Concepts useful for teaching

- Add to your own CT knowledge.
- Help students to learn uses of CT to represent and help solve problems within the various disciplines.
- Help students gain some underlying and/or introductory knowledge of computer science.
- Use terms associated with computing in everyday activities.
- Ask lots of CT questions; encourage students to ask lots of questions and plan strategies to solve them.

Resources

- Computational Thinking Jeannette Wing, CMU
- Beginner Developer Learning Center Bit & Bytes and Kids Corner, Microsoft
- LifeLong Kindergarten Mitch Resnick, MIT
- Great Principles of Computing Peter Denning, Naval Postgraduate School

Thank you

- Jeannette Wing, Carnegie Mellon
- Mitch Resnick, MIT
- Peter Denning, Naval Postgraduate School
- Marc Prensky
- Microsoft for the Computational Thinking handout